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ICT Specific Technological Changes in Precision Agriculture Environment

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Abstract: Improving farm productivity is essential for increasing farm profitability and fulfilling the rapidly growing demand for food that is fuelled by fast population growth throughout the world. Farm productivity can be raised by understanding and forecasting crop performance in many different environmental conditions. Crop recommendation is presently based on data gathered in field-based agricultural research that capture crop performance under a variety of ailments (e.g., soil quality and environmental conditions). The standard of manually collected crop performance data is extremely low, since it doesn't take into account earlier conditions that have not been observed by the individual operators. Emerging Internet of Things (IoT) technologies, such as IoT devices (e.g., wireless sensor networks, network-connected weather stations, cameras, and smart telephones) can be used to collate vast number of harvest and environmental performance data, ranging from time series data from detectors, to spatial data from cameras, to individual observations accumulated and recorded via cellular smart phone software. Such data can then be analyzed to filter out invalid data and compute personalized crop recommendations for any particular farm. In this report, the IoT-based study that may automate the selection of ecological, soil, fertilization, and irrigation information; mechanically correlate such data and filter-out invalid data from the view of assessing crop operation; and compute crop predictions and personalized harvest recommendations for any particular farm are introduced.
Keywords: IoT, Precision Agriculture, Soil Quality

1. Introduction

Improving farm productivity requires crop performance to be understood and forecasted under a wide variety of environmental, soil, fertilization, and irrigation conditions. The productivity of a farm can be enhanced by determining which crop variety has produced the greatest yield under the similar soil, climate, fertilization, and irrigation conditions. The same data-driven approach to crop selection can also address climate change, resource constraints (water, labor, and energy shortages), and societal concerns around issues such as animal welfare, fertilizers, and environment that often impact agricultural production [1]. According to the United Nations' Food and Agriculture Organization [2], food production must increase by 60% by 2050 to be able to feed the growing population, expected to reach 9 billion. Increased crop productivity is urgently needed, and it is the cornerstone of any solution for meeting food shortage and farm profitability problems. Smart farming involves the use of Information

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Communication Technologies (ICT) and in particular, the Internet of Things (IoT) and related big data analytics to address these challenges via the electronic monitoring of crops, as well as related environmental, soil, fertilization, and irrigation conditions. Such monitoring data can be then be analyzed to identify which crops and specific crop varieties can best meet the productivity targets of any particular farm around the world.

The main contributions of this report are summarized as follows:
(i) The potential of using wireless communications protocols or technologies in agriculture was investigated.
(ii) The taxonomy of data analytics in agriculture and to identify those methods those are most suitable for solving smart agriculture problems.
(iii) The existing solutions, applicability, and limitations of applying Decision Support System (DSS) in agriculture were reviewed and compared.
(iv) Recent studies based on Internet of Things (IoT) in PA are surveyed and compared in terms of the type of sensors and actuators, IoT devices, IoT platforms, and IoT application layer.

2. Background

2.1 Precision Agriculture

Precision agriculture is a principle of management of agricultural parcels appeared in the United States in the 1980s. Already in 1985, researchers from the University of Minnesota vary the intake of calcium amendments on agricultural plots. The experimental procedure involves the application of certain inputs (nitrogen, phosphorus, potassium) in certain high-energy-intensive crops and inputs (maize, sugar beet for example), in the context of the race to progress agricultural yields.

Mainly precision farming aims at optimizing yields and investments [1, 2, and 3], seeking to better account for the variability of environments and improving conditions between different plots. It has influenced tillage, seeding, fertilization, irrigation and pesticide spraying.

In practice, the aim is to optimize the management of a plot from a triple point of view:

- Agronomic: The agronomic precision aims at improving the efficiency of inputs/yields, including the choice of strains and varieties more adapted to the phytosanitary context.
- Environmental: It also involves reducing certain risks to human health and the environment (in particular by reducing the environmental release of nitrates, phosphates, and pesticides).
- Economic: Increase yields, while reducing energy consumption, water usage, and chemical inputs.

2.2 Internet of Things

The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

So, basically, IoT is any device that reduces a human's effort in doing some daily and needful actions.

Figure 1: Internet of Things (IoT)

A thing, in the Internet of Things, can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is low -- or any other natural or man-made object that can be assigned an IP address(unique address to identify every individual device) and provided with the ability to transfer data over a network.

IoT has evolved from the convergence of wireless technologies, micro-electromechanical systems (MEMS), micro-services and the internet. The convergence has helped tear downthe silo walls between operational technologies (OT) and information technology (IT), allowing unstructured machine-generated data to be analyzed for insights that will drive improvements.
Practical applications of IoT technology can be found in many industries today, including precision agriculture, building management, healthcare, energy, and transportation.

3. Recent Research

In the time of increasing demand for food, precision agriculture provides higher yields with a lower input cost and leads to a reduction in environmental pollution and labor (Shirish and Bhalerao, 2013) [4]. Modern day food production and precision agriculture are expected to dramatically increase the usage of the latest computer and electronic technologies (Cho, 2012) [5]. In accordance with this, decision support systems have been developed in the last decades in order to provide the expert knowledge needed for farmers in their agricultural management. In Rossi et al. (2014) [6], the authors present a good example of such solution, which is designed to help grapevine farmers make the right decision on the proper time for pesticide treatment based on sustainable agriculture.

In recent years, the development of information and communication technology (ICT) resulted in the emergence of two important concepts that affect the world around us: Internet-of-Things (IoT) and Cloud computing (Mell and Grance, 2011) [11]. Both concepts are expected to be put to use in agriculture on a much larger scale in the near future (Vermesan and Friess, 2013) [8]. The IoT is a network of physical objects (i.e. devices, vehicles, buildings) instrumented with

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embedded electronics, sensors, software, and networking connectivity enabling these objects to collect and exchange data (Ojha et al., 2015) [9]. The IoT equips objects of interest to be sensed and controlled remotely over the existing and future network infrastructure, which creates various opportunities to integrate physical objects with computer-based systems. The main goals of IoT include improved efficiency, accuracy, economic gains, and better quality of life (Holler, 2014) [10]. Cloud computing is based on the utilization of computer resources (processors, memory, storage, network), which can be located and managed remotely. Cloud computing service models include infrastructure-as-a-service (IaaS), platform-as-a-service (PaaS), and software-as-a-service (SaaS). Clouds can be deployed as public, private, or hybrid (Mell and Grance, 2011) [11]. Our goal is to implement a private IoT cloud platform that can be used as a foundation for research and development in the domains of precision agriculture and ecological monitoring. The mission of the project is to create a research and development platform in the areas of sustainable agriculture, monitoring of the crops, forest and water ecosystems, development of techniques for controlling and reducing pollution, analysis and standardization of food products, control of land quality, and improvement of the public health (Fig. 1). The project is focusing on the utilization of IoT and Cloud to support the adoption of these novel technologies and innovations in the areas of precision agriculture and ecological monitoring.

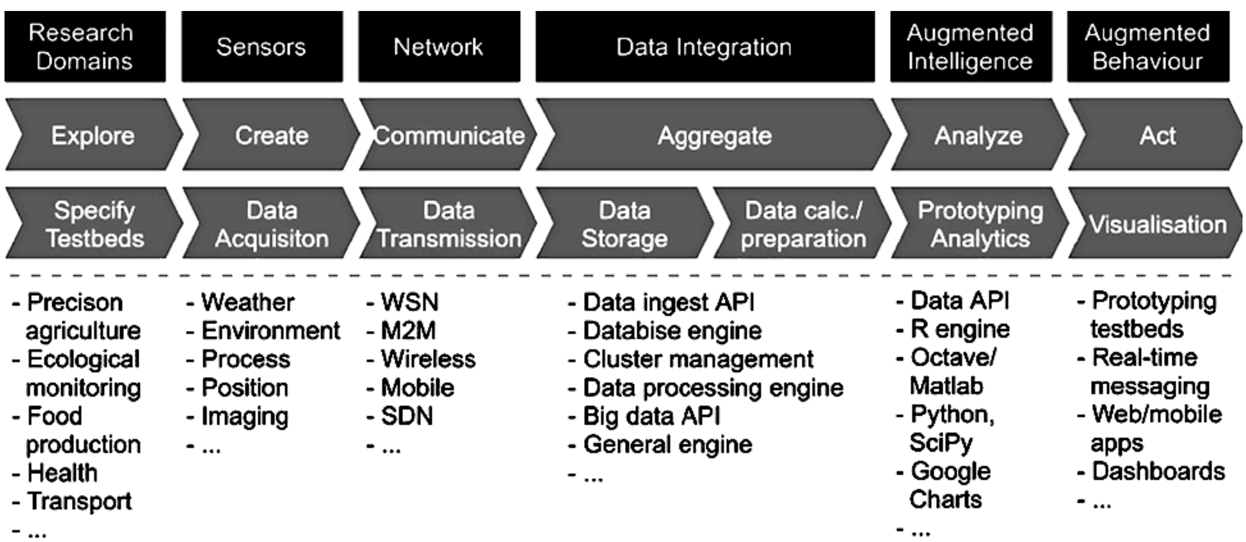

Fig. 1. Concept: an IoT-enabled research and development platform.

Designing and implementing computer and electronics systems, especially IoT, in the domains of precision agriculture and ecological monitoring can be challenging, therefore a systematic approach is needed (Krcˇo et al., 2014; Kruize, 2016) [12, 13]. Several IoT cloud platforms are available in the form of public cloud services (Azure IoT Suite, Amazon AWS IoT, DeviceHive and others), but main requirements in this project were to focus on private deployment and the use of open source software. Few open source IoT platforms have been evaluated (Kaa, FiWare, ThingSpeak). Among those, the ThingSpeak platform has been identified as the closest fit for the project needs (ThingSpeak IoT Platform). However, the open-source variant of that solution has

not been as active recently since it has been commercialized and offered as a public cloud service.
The list of precision agriculture use cases currently being developed is given in Table 1. These end-user applications include smart irrigation, smart soil fertilization, smart pest control (spraying), and plant disease forecasting and detection (Sekulic´ et al., 2016; Jhuria et al., 2013) [15, 16].

Table 1
Precision agriculture: high-level use case examples.

UC	Actor/Role	Use Case
1-1	Farmer	Smart irrigation
1-2	Farmer	Smart soil fertilization
1-3	Farmer	Smart spraying
1-4	Farmer	Diseases forecasting and detection

In the similar context, the precision agriculture focus is on employing remote sensing and IoT, wireless communications, cloud computing, intelligent systems, and expertise in agriculture together in order to enable implementation of various intelligent applications. Fig. 2 illustrates a context view of the IoT deployment in an agricultural environment. Several IoT sensor nodes are installed throughout the field to collect, preprocess, and transmit the measurements of interest. The IoT nodes are communicating to the servers in Cloud directly or via the gateway. Digital images may be captured by the camera nodes using filed cameras, drones, or even by accessing satellite imaging (Kale, 2015) [17]. The servers in the Cloud are used to host data integration, analytics, remote visualizations, smart applications development, and prototype deployment. Remote users can access the data and smart applications using their workstations and/or mobile devices. Field users can access the Cloud using their mobile devices.

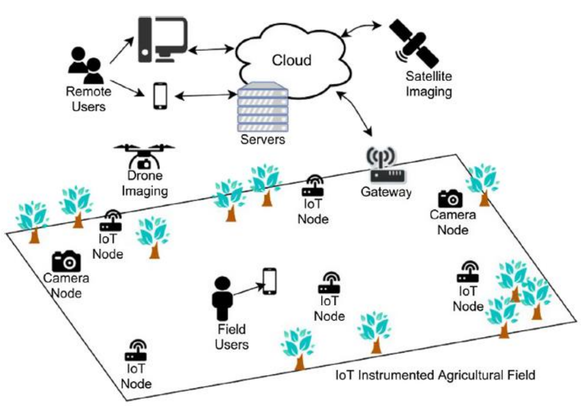

Fig. 2. Context view: precision agriculture.

For instance, the system proposed in Zou (2014) is used for online crop growth monitoring and it captures different types of variables such as temperature, humidity, soil moisture, CO2, luminosity, pH of water, and images [18]. Some representative examples of IoT applications categorized in the monitoring domain are described below.

Air monitoring: this subdomain aimed to provide periodic or continuous measurements, evaluating and determining environmental parameters or pollution levels in order to prevent negative and damaging effects. It also included the forecasting of possible changes in the ecosystem or the biosphere as a whole. For instance, in Watthanawisuth et al. (2009) authors described an agricultural IoT solution which can be categorized in the air monitoring sub-domain [19]. In this solution, authors proposed a real-time monitoring system of microclimate based on a WSN. The solution included temperature and relative humidity sensors (SHT15) powered by solar panels and supported by ZigBee communication technology. Another air monitoring IoT solution is GEMS (Lu et al., 2010), which proposed an environmental monitoring system based on GPRS technology for monitoring apple orchards [20]. This system was tested in five different regions of China over a 2-year period by monitoring variables such as relative humidity, temperature, and radiation.

Soil monitoring: papers classified in this subdomain such as (Chen et al., 2014) proposed systems for monitoring multi-layer soil temperature and moisture in a farmland fields using WSN [21]. These systems are supported by communication technologies such as ZigBee, GPRS, and Internet, where user interaction with the system is handled by a web application.

Water monitoring: primary studies categorized in this subdomain intend to monitor water pollution or water quality by sensing chemicals, pH, and temperature, which can alter the natural state of water. An example of this subdomain is presented in Postolache et al. (2013) [22], where authors proposed an IoT solution for water quality assessment through the measurement of conductivity, temperature, and turbidity. The solution is based on a WSN architecture that combines low-cost sensing devices and monitoring of multiple parameters of water quality of shallow waters (lakes, estuaries, rivers) in urban areas. Similarly, (Xijun et al., 2009) proposed a WSN system for monitoring water level and rainfall in irrigation systems [23].

Plant monitoring: The LOFAR-agro Project (Langendoen et al., 2006) is an example of the plant or crop monitoring [24]. This project aimed to protect a potato crop against Phytophthora (a genus of water mold) by monitoring the microclimate (humidity and temperature) using a large-scale WSN. The system intended to generate a policy to protect the crop against the fungal disease based on the collected data. In Fourati et al. (2014), authors propose a Web-based decision support system communicating with a WSN for irrigation scheduling in olive fields [25]. For this purpose, authors use sensors to measure humidity, solar radiation, temperature, and rain.

Animal monitoring: This subdomain referred to animal tracking for both wildlife and animal husbandry activities. A research belonging to this subdomain was a delay-tolerant WSN for the monitoring and tracking of six horses presented in Ehsan et al. (2012) [26]. For this purpose,

authors developed necklaces that acquired information about horses' position and speed at a given time and transmitted such logs to fixed nodes when they were close to its coverage area. Another example of animal monitoring was given by Jain et al. (2008) [27], where an IoT solution was responsible for monitoring the behavior and migration patterns of Swamp Deers, obtaining information of the animal position and the climate at the same time.
Papers selected and grouped under the domain of control use remote actuator devices deployed on-site. Unlike monitoring domain applications, which handle information in one-way, applications categorized in control use a two-way information channel. This means that a new level of communication was added, and commands could be sent back to the field. In this case, information from the server or data center traveled to a Wireless Sensor and Actuator Network (WSAN) in order to control a set of actuator devices to modify the state of the process or environment. Commands were sent through a human–computer interface or as a result of a decision algorithm supported by analytic modules. Actuator devices included valves, pumps, humidifiers, and alarms among others. Many of these systems aimed to optimize the usage of water, fertilizers, and pesticides based on information provided by weather prediction systems and on-site WSN. Solutions in this domain could help farmers to reduce water consumption and waste by scheduling irrigation times and quantities according to the state of the crop and its growth cycle. Control systems were programmed to be adaptive, for instance, switching off sprinkler if rain was detected. Overall, solutions with control systems could save money to the farmer and provide at the same time valuable insights about the consumption of water, fertilizers, pesticides, and electricity.

Actuator devices used by IoT solutions grouped in the control domain depended heavily on the subdomain to which they belonged. In this paper, the following subdomains were considered: irrigation (72.22%), fertilizers (5.56%), pesticides (5.56%), illumination (5.56%), and access control (5.56%). During the review, it was found that some studies used actuators in the domain of logistics (5.56%). Representative examples of IoT applications categorized in the control domain are described next.

Irrigation control: A precision irrigation solution based on wireless sensor network was proposed by Kanoun et al. (2014) [28]. The main challenge of that study was to create an automated irrigation system which could reduce water waste, saving energy, time, and money. This system was built using three nodes based on the TelosB mote: (i) a node to measure soil moisture and soil temperature; (ii) a node to measure environmental parameters such as air temperature, air humidity, wind speed and brightness; and (iii) a node that was connected to a valve for irrigation control. Data were transmitted to a base station for storage and were sent to the farmer's PC to allow him to take action. Another precision irrigation IoT system was proposed by Jiao et al. (2014) [29]. This included an environmental monitoring system for agricultural management, as well as the implementation of precision dripping. The system considered an IoT ecosystem divided into three layers corresponding to sensing, transmission, and application. A WSN was used to perceive environmental information in real time within a tomato greenhouse, to later transmit the data to a remote server management system. In Shuwen and Changli (2015) researchers described a remote farmland irrigation monitoring solution based on ZigBee [30]. The system included a solar-powered irrigation control system that also monitored air temperature, humidity and soil temperature.

Fertilizer and pesticide control: IoT solutions categorized in this subdomain applied conservation practices to improve nutrient usage, efficiency, crop quality, overall yield, and economic return while reducing off-site transport of nutrients. In Pahuja et al. (2013), authors developed an online microclimate monitoring and control system for greenhouses [31]. The system was supported by a WSN to gather and analyze plant related sensor data to produce actions to control the climate, fertilization, irrigation, and pests. Illumination control: authors in Yoo et al. (2007) described an automated agriculture system based on WSN for monitoring greenhouses used to grow melons and cabbages [32]. The system monitored the growing process of crops and controlled the greenhouse's environment. Some of the variables measured included ambient light, temperature, and humidity. For the greenhouse with melons, the system could control the illumination by changing the light state through a relay.

Access control: An agricultural intrusion detection system was presented in Roy et al. (2015) [33]. The proposed system generated alarms in the farmer's house and sent a text message to the farmer's mobile phone when an intruder entered the crop field. Selected papers categorized in the prediction domain were focused on providing knowledge and tools to farmers to support decision making. They had specific modules for these tasks in their architecture, and their predicted variables were grouped as follows: environmental conditions (42.86%), production estimation (42.86%), and crop growth (14.29%).

Environmental conditions: A representative example of environmental condition prediction is proposed in Khandani and Kalantari (2009), where authors described a design methodology to determine the spatial sampling of humidity sensors for the soil within a WSN [34]. They used a historical database of dense soil-humidity measurements to determine the behavior of the 2D correlation that exists between the measurements of nearby sensors. This was used later to find the largest spatial sampling that ensured a user-defined variance for the estimation on any given point of interest in the space. Authors found that the spatial correlation function decays exponentially with the distance between sensors. Another example of the prediction of environmental conditions was presented in Luan et al. (2015), which described a system that integrates drought monitoring and forecasting as well as irrigation prediction using IoT [35].

Production estimation: Authors in Lee et al. (2013) [36] presented an IoT-based agricultural production system for stabilizing supply and demand of agricultural products. They achieved this goal by sensing environmental variables and by developing a prediction system for the growth and yield of crops. In a different application, (Saville et al., 2015) [37] introduced a real-time estimation system for fixed-net fishery using ultrasonic sensors and supervised learning.

Crop growth: a dynamic analysis of farmlands using mobile sensors was presented in Lee et al. (2012) [38]. The developed system aimed to establish growth-control plans for grapes, and viticulture activities.

The last domain used to categorize selected studies was logistics. Logistics in agriculture refers to the physical flow of entities and related information from producer to consumer to satisfy consumer demand. It includes agricultural production, acquisition, transportation, storage, loading and unloading, handling, packaging, distribution, and related activities. Some objectives of logistics in agriculture include: adding value to agricultural products, saving money in distribution costs, improving shipping efficiency, reducing unnecessary losses, and to some extent, avoiding risks (Liping, 2012) [39]. Primary studies in logistics were further divided in production (55.6%), commerce (22.2%) and transport (22.2%). The next paragraphs include representative studies of each subdomain.

Production: in Feng et al. (2012) researchers proposed an intelligent system for monitoring an apple orchard that implemented suggestions based on data [40]. The system aimed to reduce management costs of apple orchards, improve apple quality, and provide detailed, comprehensive and accurate electronic information for planting works, pest warnings, and production-quality tracking of apples. The system included WSN using Zigbee, GPRS, and IoT providing detailed monitoring data of apple growth for agricultural cooperatives, to support for decision making in farming.

Commerce: (Li et al., 2013) presented an information system for agriculture based on IoT which used a distributed architecture. In that study, tracking and tracing of the whole agricultural production process were made with distributed IoT servers [41]. Moreover, an information-discovery system was designed to implement, capture, standardize, manage, locate, and query business data from agricultural production. The system also allowed consumers to query information of agricultural products to verify their authenticity and quality.

Transport: A representative example of this subdomain is presented in Pang et al. (2015) [42], where an IoT architecture was proposed for the food-production and commercialization chain. This paper dealt with logistics involved in the transportation of melons from Brazil to Sweden in a journey that takes 46 days. Sensor nodes measured conditions in the environment including oxygen, carbon dioxide, ethylene, temperature, humidity, and mechanical stress, such as vibrations, tilts, and shocks.

In the similar context, Foughali et al. (2017) [46] have proposed a web-based decision support system integrated with IoT sensor nodes to monitor the microclimate parameters of the farm. The complete decision is performed in the cloud platform by exploiting the internet technology. For irrigation management, Foughali et al. (2017) [46] have proposed one dashboard software in the form of a graph, to monitor in real time the variations of the soil conditions and on the other hand a process of notification by SMS will be transmitted via the application when a critical level is reached to avoid water stress.

In Duan Yan-e et al. and Nasser et al. (2011) [43, 54] proposed an IOT application that provides agricultural information and crop information to farmers on the basis of collected wireless sensor network data. This information is used to ensure that the rate of Fertilizer application and within the recommended limit. In Xiangyu HU et al. and Rajput N et al. (2012) [44, 53] Developed an IOT application for remote monitoring and control of agricultural fields, which is based on the analysis of data collected by the wireless sensor network, which has enabled farmers to minimize the cost of hand And the efficient use of water resources. In Andreas Kamilaris et al. (2014) and Dargie et al. (2012) [50, 52] have proposed an application called Agri-IOT allowing the analysis and the processing of data coming from a network of sensors (WSN) while exploiting the semantic aspects. This will make it possible to associate an easy publication of data on the semantic web.

The agriculture sector in India is diminishing day by day which affects the production capacity of the ecosystem. There is an exigent need to solve the problem in the domain to restore vibrancy and put it back on higher growth. Further, Mohanraj I et al. (2016) and Akyildiz et al. (2002) [47, 51] have proposed an e-Agriculture Application based on the framework consisting of KM-Knowledge base and Monitoring modules. To make profitable decisions, farmers need information throughout the entire farming cycle. The required information is scattered in various places which include real-time information such as market prices and current production level stats along with the available primary crop knowledge. A knowledge dataflow model is constructed connecting various scattered sources to the crop structures.
The true objective of IoT is to connect all ‘things', manages devices, collects data, and allows action management, analytics, and visualization and integrates with cloud services. Similarly, Li Tan (2016) [48] has developed a framework for cloud-based Decision Support and Automation systems that can acquire data from various sources, synthesize application-specific decisions, and control field devices from the Cloud. A distinctive feature of our framework is its extensible software architecture: decision modules can be added and/or configured for a specific operation. The platform features a device-agnostic frontend that can process incoming data in different formats and semantics. Finally, the platform incorporates software-defined control, a new software design paradigm we proposed to enable versatile and safe control of field devices from a cloud computing platform. In this context, Ciprian-Radu RAD et al. (2016) [49] have proposed a precision agricultural management integrated system architecture based on Cyber-Physical Systems (CPS) design technology.

Andreas Kamilaris et al. (2017) [45] have performed a review on current studies and research works in agriculture which employs the recent practice of big data analysis, in order to solve various relevant problems. Thirty-four different studies are presented, examining the problem they address, the proposed solution, tools, algorithms and data used, nature and dimensions of big data employed, the scale of use as well as overall impact. Concluding, the review highlights the large opportunities of big data analysis in agriculture towards smarter farming, showing that the availability of hardware and software, techniques, and methods for big data analysis, as well as the increasing openness of big data sources, shall encourage more academic research, public sector initiatives and business ventures in the agricultural sector. This practice is still at an early development stage and many barriers need to be overcome.

4. Research Undertaken

In this report, a detailed year wise progress of computer and electronics in agriculture has been produced in figure 3. The primary source of the study during this review is performed on the articles from Elsevier.

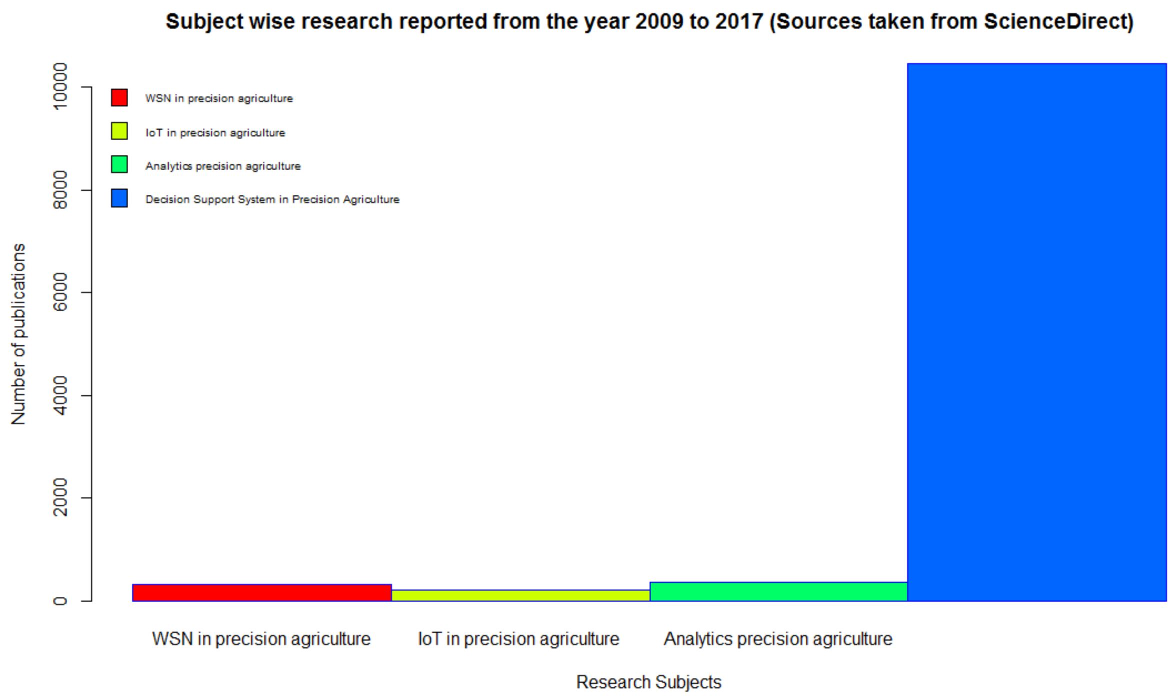

Figure 3: Subject wise research reported from the year 2009 to 2017 on various aspects of computer and electronics in agriculture

Similarly, the IoT based research in precision agriculture has different building blocks which include lots of sensors, software's, network components and other electronic devices. All these individual elements are required to fulfill the specific requirement. In this review work, the water management and soil management related to IoT are considered for the study. The major technology stacks studied for this review are WSN, IoT, Analytics, and DSS. The statistics of year wise research work reported on these areas are shown in figure 4, figure 5, figure 6 and figure 7.

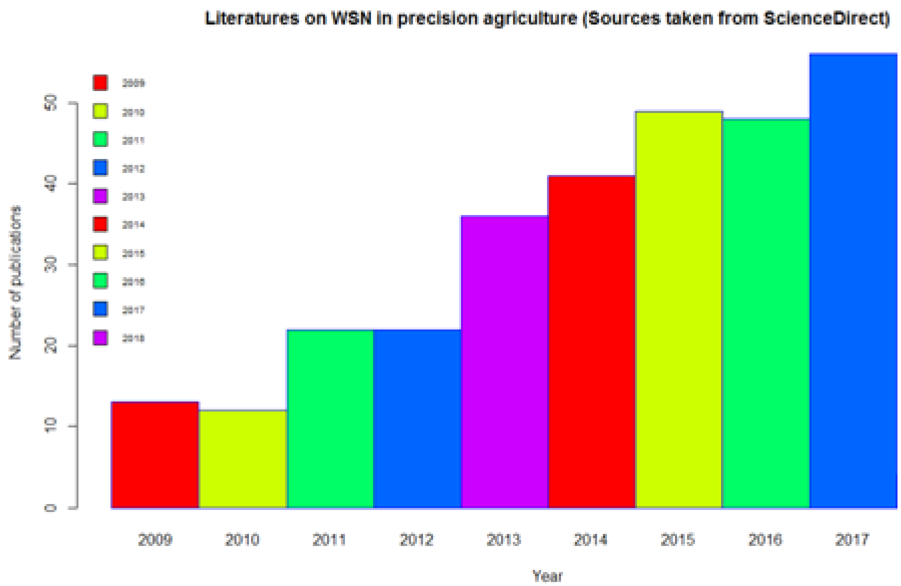

Figure 4: Year-wise research reported on Wireless Sensor Network (WSN) in Precision Agriculture (PA)

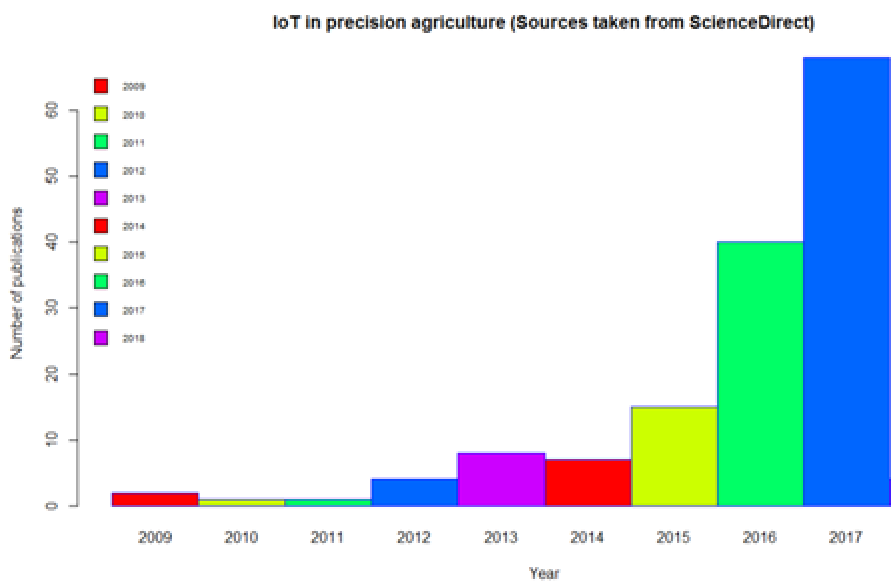

Figure 5: Year-wise research reported on Internet of Things (IoT) in Precision Agriculture (PA)

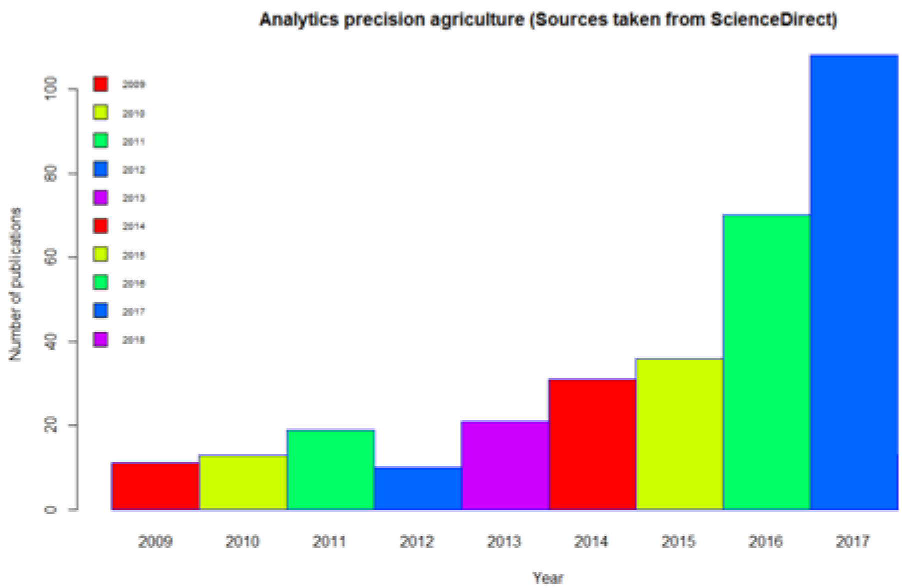

Figure 6: Year-wise research reported on Data Analytics in Precision Agriculture (PA)

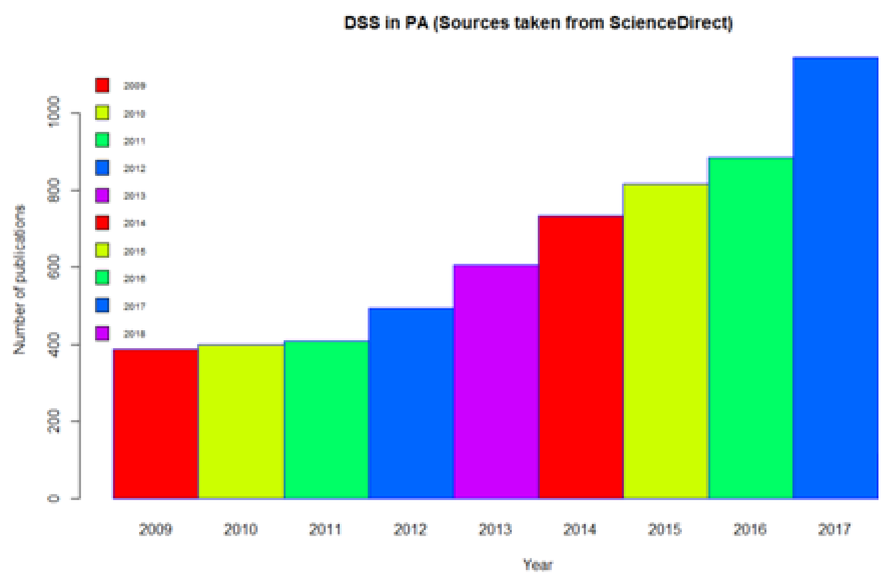

Figure 7: Year-wise research reported on Decision Support System (DSS) in Precision Agriculture (PA)

5. Conclusion

Now a day there's vast enhancement in technology, different tools and techniques can be found in agriculture industry. To improve efficiency, productivity, international market and to reduce human intervention, cost and time there is a requirement to divert towards new technologies called Internet of Things. IoT is the system of devices to transfer the data without human participation. Hence, to acquire high productivity, IoT works in combination with agriculture to acquire smart farming. Thus there is need of farming. Internet of Things can help enhance smart farming. IoT works in various domains of farming to improve energy efficiency, water management, crop monitoring, soil management, management of insecticides and pesticides etc.. Apart from these diversified program domains, many other technological improvements such as Wireless Sensor Network (WSN), Data Analytics, IoT framework and Decision Support System (DSS) are also required for core performance IoT from Precision Agriculture (PA). It also minimizes human attempts, simplifies methods of farming and aids to gain farming. Along with these characteristics smart farming can help increase the market for farmer with single touch and minimal efforts.

References

1. L. Karim, A. Anpalagan, N. Nasser, J. Almhana, 2013, Sensor-based M2M agriculture monitoring systems for developing countries: state and challenges, Netw. Protoc. Algor., pp. 68-86.
2. E. Lichtenberg, J. Majsztrik, M. Saavoss, 2015, Grower demand for sensor-controlled irrigation, Water Resour. Res., 51.
3. Alberto Reche, Sandra Sendra, Juan R. Diaz, 2014, Jaime Lloret: A Smart M2M Deployment to Control the Agriculture Irrigati on. ADHOC-NOW Workshops, pp. 139-151
4. Shirish, P., Bhalerao, S., 2013, Precision farming: the most scientific and modern approach to sustainable agriculture. Int. Res. J. Sci. Eng. 1 (2), pp. 21–30.
5. Cho, Y. et al., 2012. An Agricultural Expert Cloud for a Smart Farm. Springer, Dordrecht.
6. Rossi, V., Salinari, F., Poni, S., Caffi, T., Bettati, T., 2014. Addressing the implementation problem in agricultural decision support systems: the example of vite.net_. Comp. Electron. Agricult. 100, pp. 88–99.
7. Rozanski, N., Woods, E., 2011. Software Systems Architecture: Working With Stakeholders Using Viewpoints and Perspectives. Addison-Wesley Professional.
8. Vermesan, O., Friess, P., 2013. Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems. River Publishers, Aalborg, Denmark.
9. Ojha, T., Misra, S., Raghuwanshi, N.S., 2015. Wireless sensor networks for agriculture: the state-of-the-art in practice and future challenges. Comp. Electron. Agriculture. 118, pp. 66–84.
10. Holler, J. et al., 2014. From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence. Elsevier, Atlanta.
11. Mell, P., Grance, T., 2011. The NIST Definition of Cloud Computing, NIST Special Publication 800-145, pp. 1–7.
12. Krcˇo, S., Pokric´ , B., Carrez, F., 2014. Designing iot architecture(s): a European perspective. In: 2014 IEEE World Forum on the Internet of Things (WF-IoT), pp. 79–84.
13. Kruize, J.W. et al., 2016. A reference architecture for farm software ecosystems. Comp. Electron. Agriculture. 125, pp. 12–28.
14. ThingSpeak IoT Platform <https://github.com/iobridge/thingspeak>.
15. Sekulic´ , P., Djukanovic´ , S., Djurovic´ , I., 2016. Detection of downy mildew in grapevine leaves using support vector machine. In: Proceedings of the 21st Information Technology IT'16 Conference. Zˇabljak, Montenegro, pp. 169–172.
16. Jhuria, M., Kumar, A., Borse, R., 2013. Image processing for smart farming: detection of disease and fruit grading. In: 2013 IEEE Second International Conference on Image Information Processing, pp. 521–526.
17. Kale, S. et al., 2015. Data and monitoring needs for a more ecological agriculture. Int. J. Adv. Res. Comp. Sci. Softw. Eng. 5 (12), pp. 804–807.
18. Zou, C.-J., 2014. Research and implementation of agricultural environment monitoring based on internet of things. In: 5th International Conference on Intelligent Systems Design and Engineering Applications (ISDEA). IEEE, pp. 748–752. http://dx.doi.org/10.1109/ISDEA.2014.17.
19. Watthanawisuth, N., Tuantranont, A., Kerdcharoen, T., 2009. Microclimate real-time monitoring based on zigbee sensor network. In: Sensors. IEEE, pp. 1814–1818.

20. Lu, S., Duan, M., Zhao, P., Lang, Y., Huang, X., 2010. GPRS-based environment monitoring system and its application in apple production. International Conference on Progress in Informatics and Computing (PIC), vol. 1. IEEE, pp. 486–490. http://dx.doi.org/10.1109/PIC.2010.568757.

21. Chen, K.T., Zhang, H.H., Wu, T.T., Hu, J., Zhai, C.Y., Wang, D., 2014. Design of monitoring system for multilayer soil temperature and moisture based on WSN. In: International Conference on Wireless Communication and Sensor Network (WCSN). IEEE, Wuhan, pp. 425–430. http://dx.doi.org/10.1109/WCSN.2014.9.

22. Postolache, O., Pereira, M., Gir ao, P., 2013. Sensor network for environment monitoring: water quality case study. In: 4th Symposium on Environmental Instrumentation and Measurements, pp. 30–34.

23. Xijun, Y., Limei, L., Lizhong, X., 2009. The application of wireless sensor network in the irrigation area automatic system. In: International Conference on Networks Security, Wireless Communications and Trusted Computing (NSWCTC), vol. 1. IEEE, pp. 21–24.

24. Langendoen, K., Baggio, A., Visser, O., 2006. Murphy loves potatoes experiences from a pilot sensor network deployment in precision agriculture. 20th International Parallel and Distributed Processing Symposium (IPDPS), vol. 2006. IEEE, Rhodes Island, pp. 1530–2075. http://dx.doi.org/10.1109/IPDPS.2006.163941.

25. Fourati, M.A., Chebbi, W., Kamoun, A., 2014. Development of a web-based weather station for irrigation scheduling. In: 3rd International Colloquium in Information Science and Technology (CIST). IEEE, pp. 37–42. http://dx.doi.org/10.1109/CIST.2014.701659.

26. Ehsan, S., Bradford, K., Brugger, M., Hamdaoui, B., Kovchegov, Y., Johnson, D., Louhaichi, M., 2012. Design and analysis of delay-tolerant sensor networks for monitoring and tracking free-roaming animals. IEEE Trans. Wireless Commun. 11, pp. 1220–1227. http://dx.doi.org/10.1109/TWC.2012.012412.111405.

27. Jain, V.R., Bagree, R., Kumar, A., Ranjan, P., 2008. wildCENSE: GPS based animal tracking system. In: International Conference on Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP), pp. 617–622. http://dx.doi.org/10.1109/ISSNIP.2008.4762058.

28. Kanoun, O., Khriji, S., El Houssaini, D., Viehweger, C., Jmal, M.W., Abid, M., 2014. Precision irrigation based on wireless sensor network. IET Sci. Meas. Technol. 8, pp. 98–106. http://dx.doi.org/10.1049/iet-smt.2013.0137.

29. Jiao, J., Ma, H., Qiao, Y., Du, Y., Kong, W., Wu, Z., 2014. Design of farm environmental monitoring system based on the internet of things. Adv. J. Food Sci. Technol. 6, pp. 368–373.

30. Shuwen, W., Changli, Z., 2015. Study on farmland irrigation remote monitoring system based on ZigBee. In: International Conference on Computer and Computational Sciences (ICCCS). IEEE, pp. 193–197.

31. Pahuja, R., Verma, H., Uddin, M., 2013. A wireless sensor network for greenhouse climate control. IEEE Pervasive Comput. 12, pp. 49–58.

32. Yoo, S.E., Kim, J.E., Kim, T., Ahn, S., Sung, J., Kim, D., (2007). A2S automated agriculture system based on WSN. In: IEEE International Symposium on Consumer Electronics, pp. 1–5. http://dx.doi.org/10.1109/ISCE.2007.4382216.

33. Roy, S.K., Roy, A., Misra, S., Raghuwanshi, N.S., Obaidat, M.S., 2015. AID: A prototype for agricultural intrusion detection using wireless sensor network. In: International Conference on Communications (ICC). IEEE, pp. 7059–7064.

34. Khandani, S.K., Kalantari, M., 2009. Using field data to design a sensor network. In: 43rd Annual Conference on Information Sciences and Systems (CISS), pp. 219–223. http://dx.doi.org/10.1109/CISS.2009.5054720.

35. Luan, Q., Fang, X., Ye, C., Liu, Y., 2015. An integrated service system for agricultural drought monitoring and forecasting and irrigation amount forecasting. In: 23rd International Conference on Geoinformatics. IEEE, pp. 1–7.

36. Lee, M., Hwang, J., Yoe, H., 2013. Agricultural production system based on IoT. In: 16th International Conference on Computational Science and Engineering (CSE). IEEE, pp. 833–837.

37. Saville, R., Hatanaka, K., Wada, M., 2015. ICT application of real-time monitoring and estimation system for set-net fishery. In: OCEANS, pp. 1–5.

38. Lee, J., Kang, H., Bang, H., 2012. Dynamic crop field analysis using mobile sensor node. In: International Conference on ICT Convergence (ICTC), pp. 7-11. http://dx.doi.org/10.1109/ICTC.2012.6386766.

39. Liping, W., 2012. Study on agricultural products logistics mode in Henan Province of China. In: Software Eng. Knowledge Eng.: Theory Practice. Springer, pp. 635–640.

40. Feng, C., Wu, H.R., Zhu, H.J., Sun, X., 2012. The design and realization of apple orchard intelligent monitoring system based on internet of things technology. Advanced Materials Research, vol. 546. Trans Tech Publ, pp. 898–902.

41. Li, M., Chen, G., Zhu, Z., 2013. Information service system of agriculture IoT. Automatika - J. Control, Meas. Electron. Comput. Commun. 54, pp. 415–426.

42. Pang, Z., Chen, Q., Han, W., Zheng, L., 2015. Value-centric design of the internet-of-things solution for food supply Chain: value creation, sensor portfolio and information fusion. Inform. Syst. Front. 17, pp. 289–319. http://dx.doi.org/10.1007/s10796-012-9374-9.

43. Duan Yan-e, Design of Intelligent Agriculture Management Information System Based on IoT Fourth International Conference on Intelligent Computation Technology and Automation 2011, pp. 1045 – 1049.

44. Xiangyu Hu, S. Q. (n.d.). 2012, IOT Application System with Crop Growth Models in Facility Agriculture. IEEE

45. Andreas Kamilaris, Feng Gao, Francesc X. Prenafeta-Boldú and Muhammad Intizar Ali, 2016, Agri-IoT: A Semantic Framework for Internet of Things-enabled Smart Farming Applications. In Proc. of the IEEE World Forum on Internet of Things (WF-IoT), Reston, VA, USA.

46. Foughali Karim,Fathalah Karim,Ali frihida, 2017, Monitoring system using web of things in precision agriculture. Procedia Computer Science. 110, pp. 402–409.

47. Mohanraj I, Kirthika Ashokumar, Naren J, 2016. Field Monitoring and Automation using IOT in Agriculture Domain. Procedia Computer Science. 93, pp. 931 – 939.

48. Li Tan, 2016. Cloud-based Decision Support and Automation for Precision Agriculture in Orchards. IFAC-PapersOnLine, pp. 330–335.

49. Ciprian-Radu RAD, Olimpiu HANCU, Ioana-Alexandra TAKACS, Gheorghe OLTEANU, Smart Monitoring of Potato Crop: A Cyber-Physical System Architecture Model in the Field of Precision Agriculture. Agriculture and Agricultural Science Procedia 6, pp. 73 – 79.

50. Andreas Kamilaris, Andreas Kartakoullis, Francesc X. Prenafeta-Boldú, 2017. A review on the practice of big data analysis in agriculture, Computers and Electronics in Agriculture. 143, pp. 23–37.

51. I.F. Akyildiz, W. Su, Y. Sankar a subramaniam, E. Cayirci, 2002, A survey on sensor networks‖, IEEE Communications Magazine, 40 (8), pp. 102–114.
52. Dargie, W, Fac. of Computer. Sci., Tech. Univ. of Dresden, Dresden, Germany, 2012, Dynamic Power Management in Wireless Sensor Networks: State-of-the-Art‖, IEEE Sensors Journal, 12 (5), pp: 1518 – 1528.
53. Rajput N, Gandhi N, Saxena L, Sch. of Computer. & Syst. Sci., Jawaharlal Nehru Univ., New Delhi, India, 2012, Wireless Sensor Networks: Apple Farming in Northern India‖, IEEE Fourth International Conference on Computational Intelligence and Communication Networks (CICN), pp. 218 – 221.
54. Karim L, Nasser N, El Salti T, Sch. of Computer. Sci., Univ. of Guelph, Guelph, ON, Canada, 2011, Efficient Zone-based Routing Protocol of Sensor Network in agriculture monitoring systems‖, International Conference on Communications and Information Technology (ICCIT), pp. 167 – 170.